Electronics III
Sensors

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Sensor Defined.

- A device that responds to a stimulus, such as heat, light, or pressure, and generates a signal that can be measured or interpreted.

Examples

- MAF
- ECT
- CHT
- VSS
- TCS
- TP
- O^2 SENSOR
- TR
- FRP
- DPFEGR
- CKP
- CMP

Types of sensors

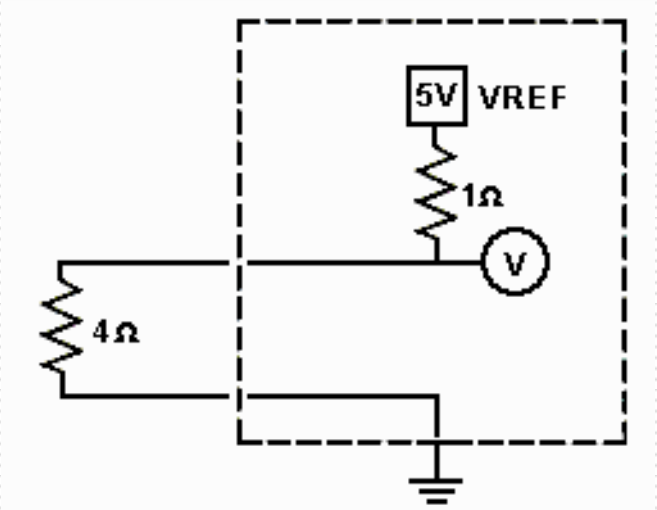
- Temperature sensor
- Position sensor
- On/Off position sensor
- Ground side switching
- Power side switching
- Magnetic pickup sensor
- Oxygen sensor
- Frequency generator
- Hall effect device
- Hot wire sensor
- Piezoelectric devices
- Knock sensors
- Piezoelectric pressure sensors
- Optical sensors

VREF, Signal, Signal Return

- "VREF" Reference voltage:
  - 5.0 volts is created by the module and sent to every sensor.
  - The VREF is the used by the variable resistors in the circuits.
- Signal:
  - The sensor conditioned signal which is returned to the module as an input.
- Signal Return:
  - Signal return is an internal to the module ground for some sensors.

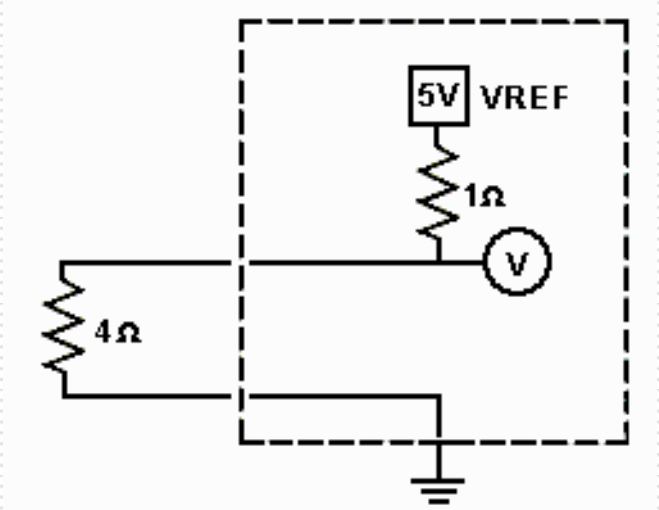
Voltage Dividing circuits

- When resistors are connected in series across a voltage source, the series resistors serve as a voltage divider circuit.
- Each resistor drops part of the applied voltage, and the sum of the series voltage drops equals ?????

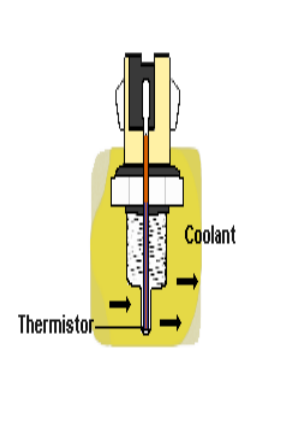


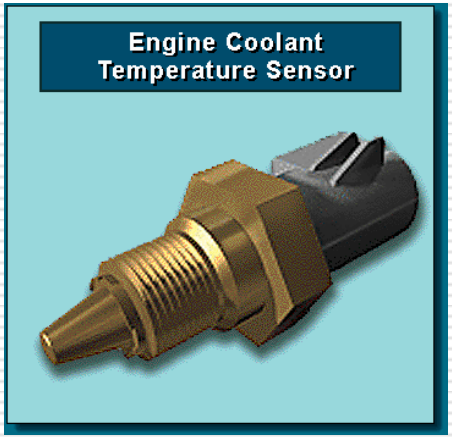
Voltage Dividing circuits

- When resistors are connected in series across a voltage source, the series resistors serve as a voltage divider circuit.
- Each resistor drops part of the applied voltage, and the sum of the series voltage drops equals source voltage



Temperature sensor "Thermistor"



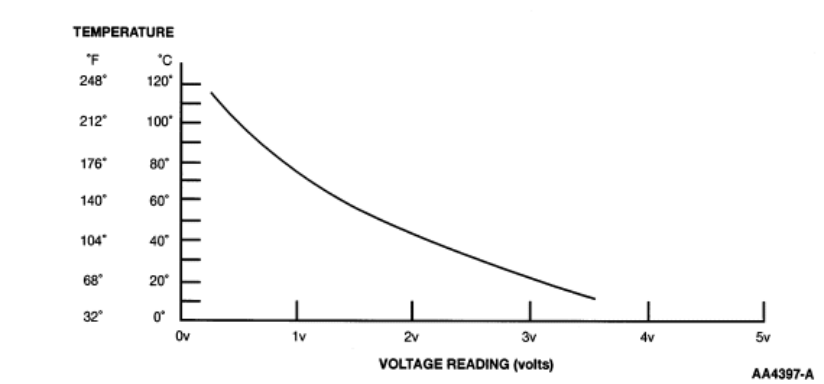


- Used to monitor various temperatures of components, fluids, and air
- Thermistor:
  - A resistor that changes its resistance with temperature change.
- Voltage dividing circuit

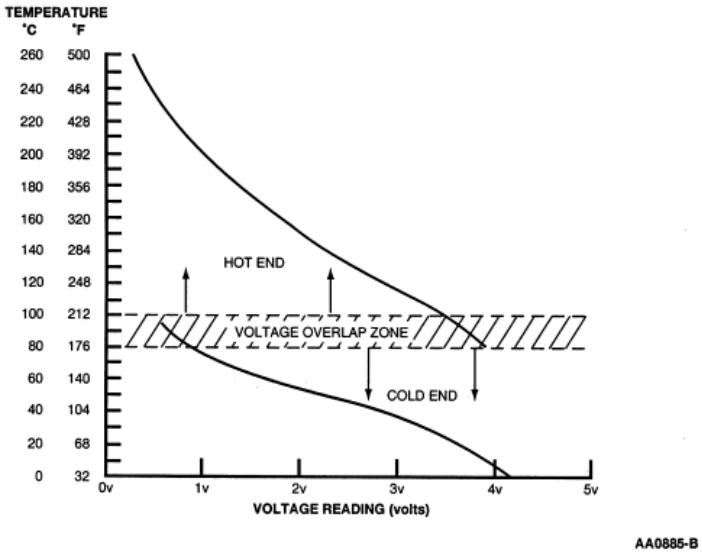
Temperature sensor "coefficient"

- PTC:
  - The higher the temperature the higher the resistance of the sensor
- NTC:
  - The higher the temperature the lower the resistance of the sensor

Temperature sensor
IAT ECT

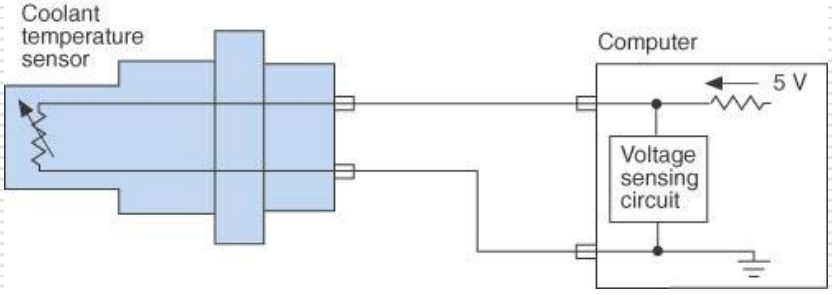


Temperature sensor "Cylinder Head Temp."



- On applications that do not use a ECT sensor, the CHT sensor is used to determine the engine coolant temperature.
- Cylinder head temps. exceed normal ECT.
- To cover the entire temperature range of both the CHT and ECT sensors, the PCM has a dual switching resistor circuit on the CHT input.
- NTC

ECT,IAT,TFT,CHT,AAT

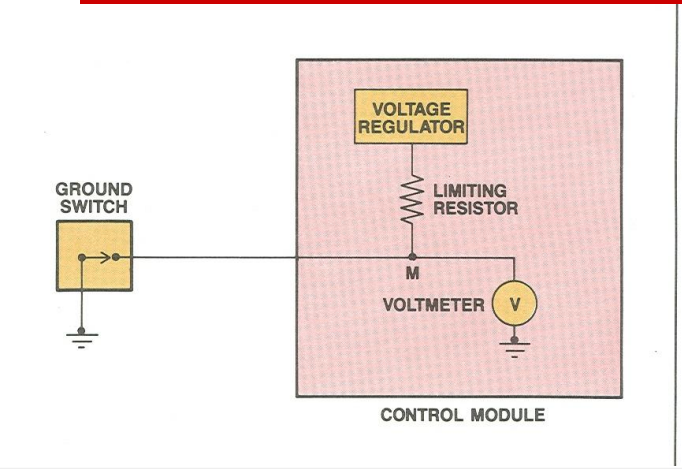


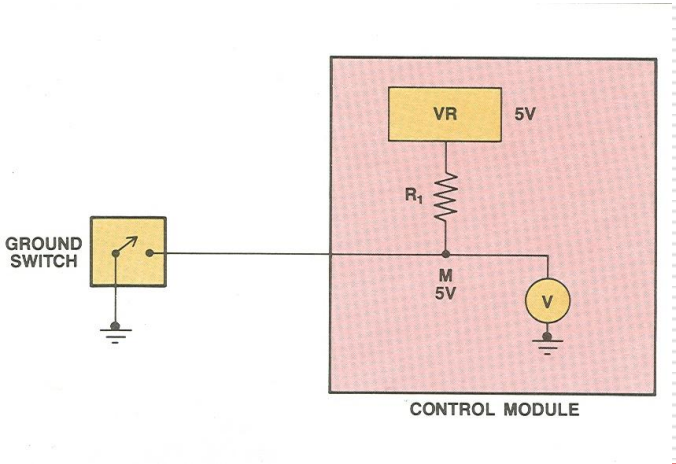
- The higher the resistance the higher the voltage (PID)
- The higher the resistance the higher the voltage.

On/Off Position Sensor

- Used to monitor the position of a component in one of two positions, also relays the state of circuits.
- GEM module monitoring front wiper motor position.
- Fuel injector circuit integrity. (INJF)

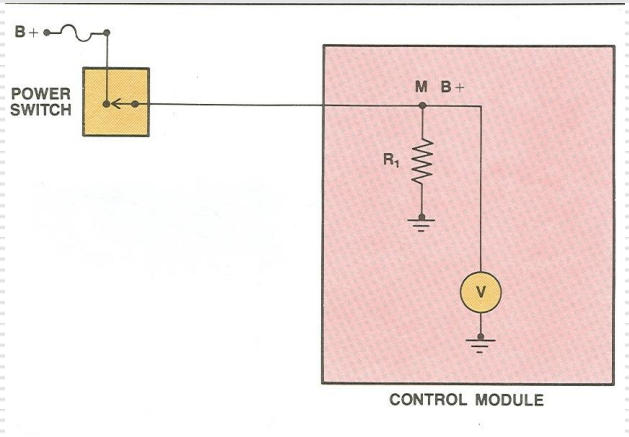
Ground Side Switching

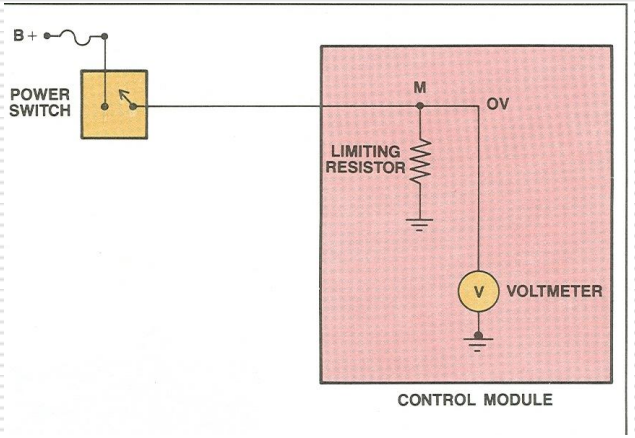




- A ground side switch is connected in series with a limiting resistor.
- Similar in operation to temp. sensor, but there is no thermistor.
- Switch closed = 0v
- Switch open = 5v

Power Side Switching



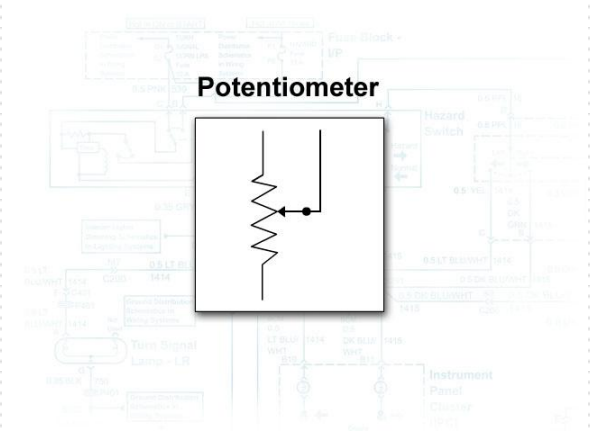


- A power side switch is connected in series with a limiting resistor.
- Similar in operation to temp. sensor, but there is no thermistor.
- Switch closed = 12v
- Switch open = 0v

Term Review

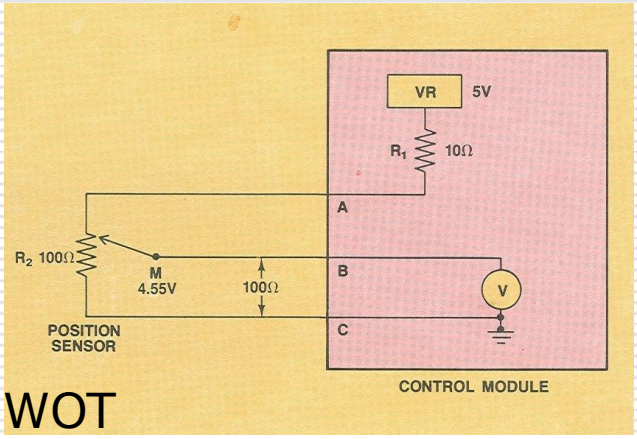
- Sensor
- Input
- VREF
- Signal Return
- Thermistor
- PTC
- NTC
- CHT
- Ground Side Switch
- Power Side Switch

Position sensor "Potentiometer"



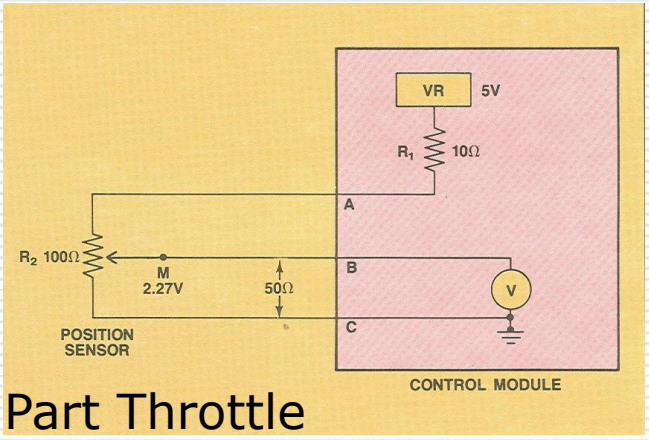
- An electronic device which provides a position input from driver command or module output.
- Can relay linear or rotary position.
- Voltage dividing circuit.
- Uses:
  - TP
  - EVP

Position sensor "Potentiometer"

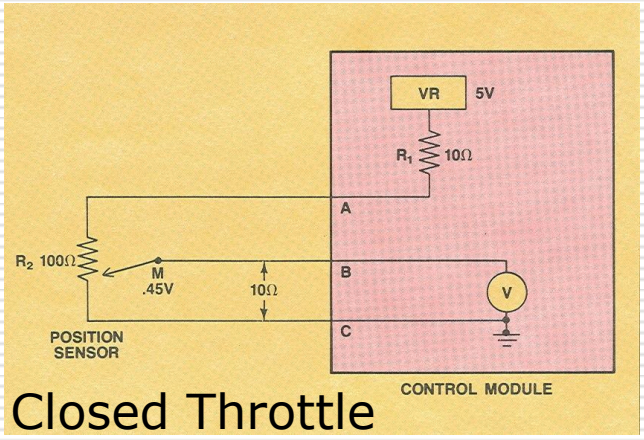


WOT

The module monitors the voltage drop on the signal and signal return circuits

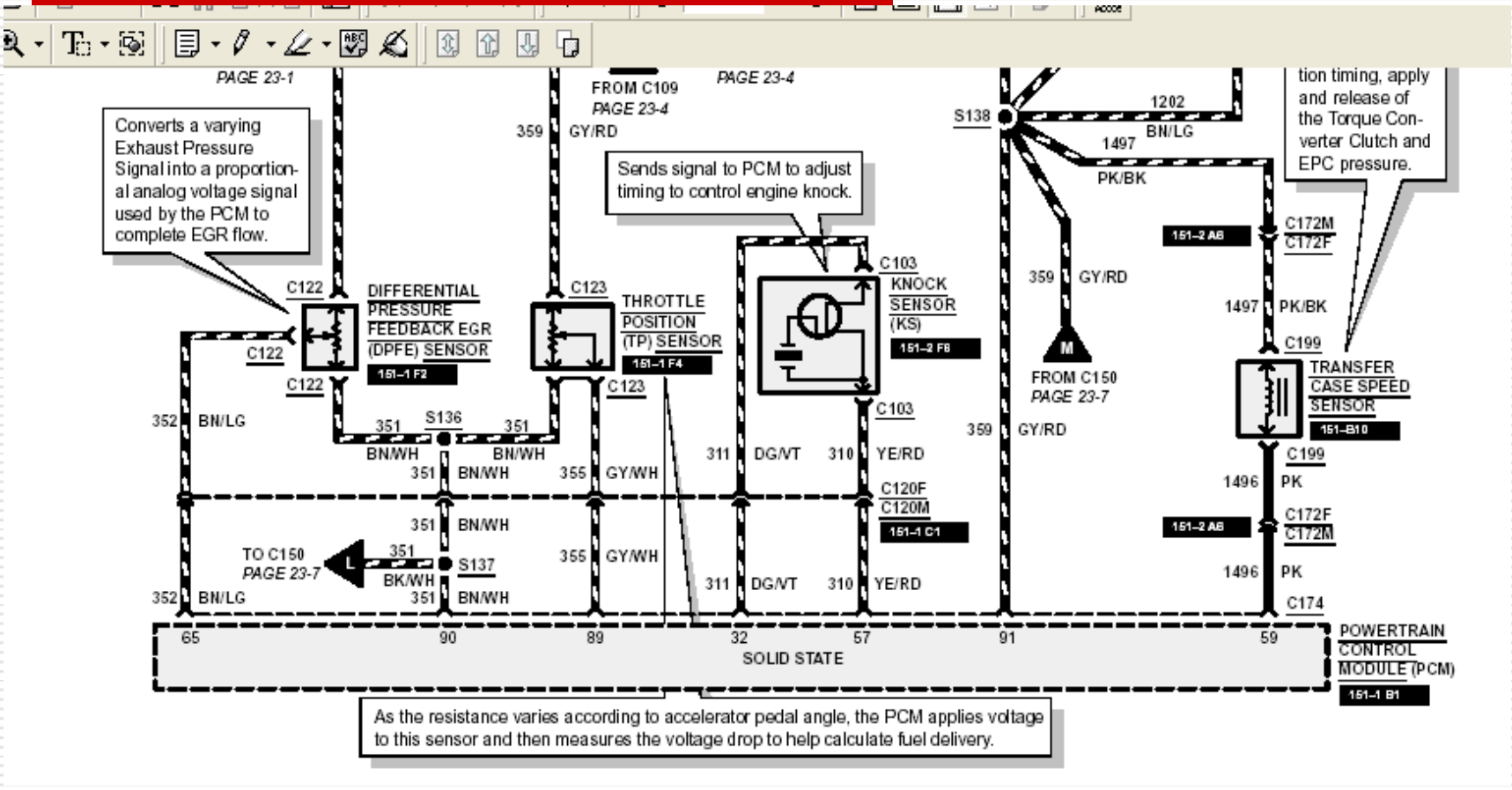


Part Throttle

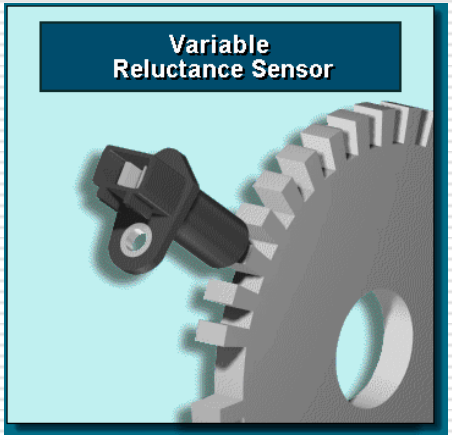


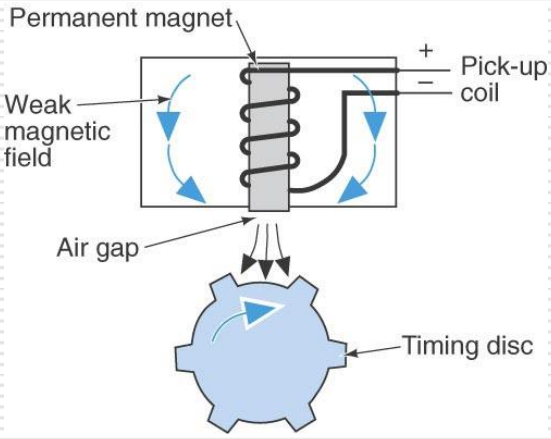
Closed Throttle

CKT 351 = VREF
CKT 355 = Signal
CKT 359 = Signal Return



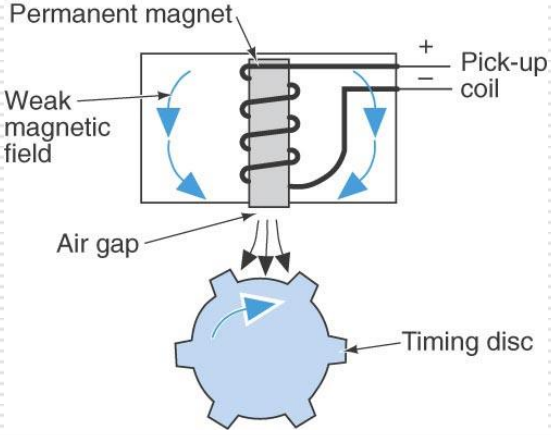
Magnetic Pickup Sensor VRS

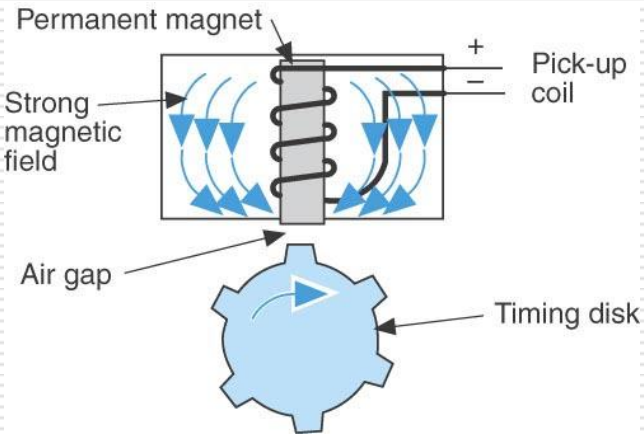




- Variable reluctance
- Produces its own voltage (AC)
- Components:
  - Exciter wheel
  - VRS sensor
- Used to relay rotational speed.

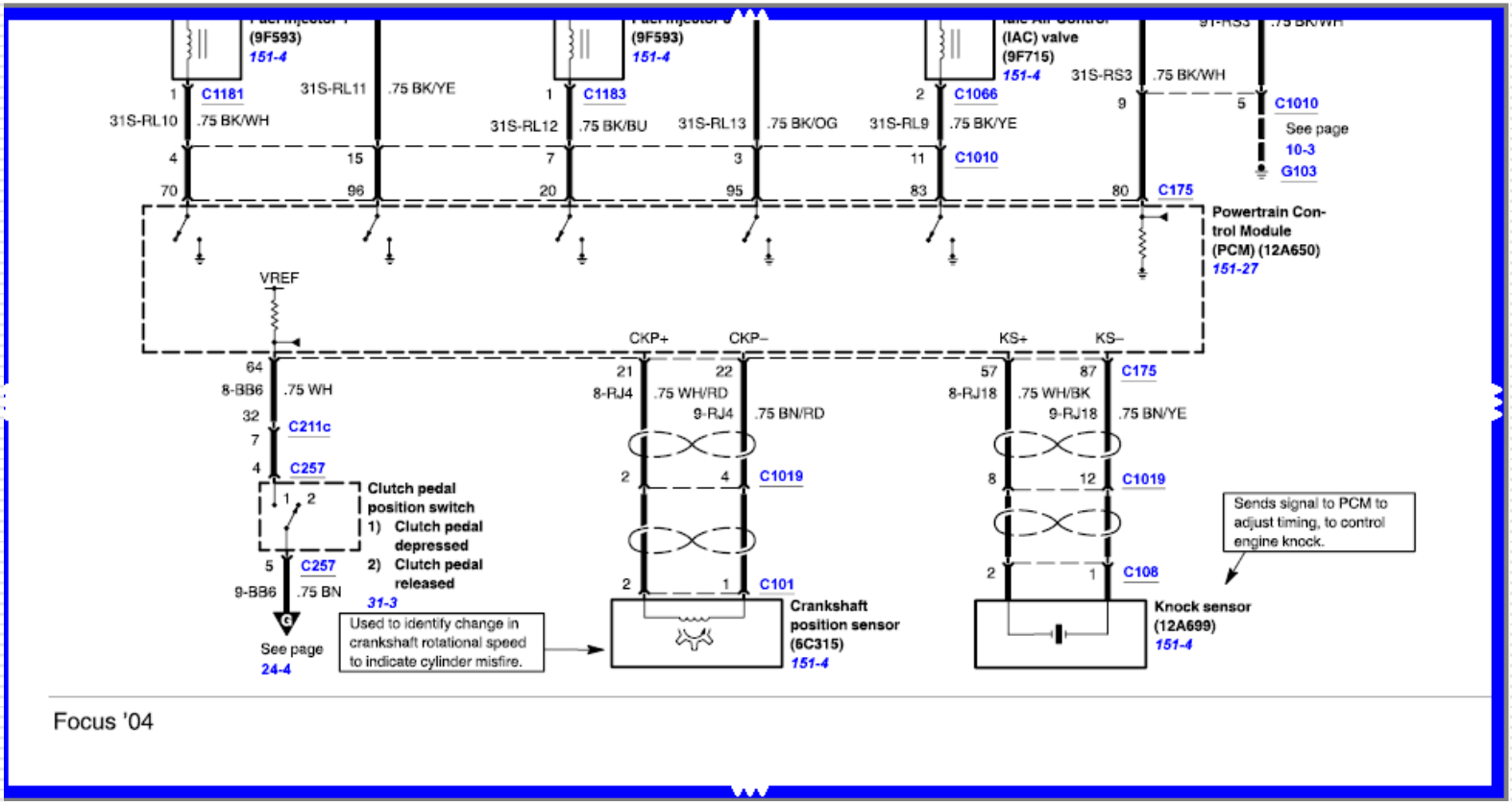
Magnetic Pickup Sensor VRS



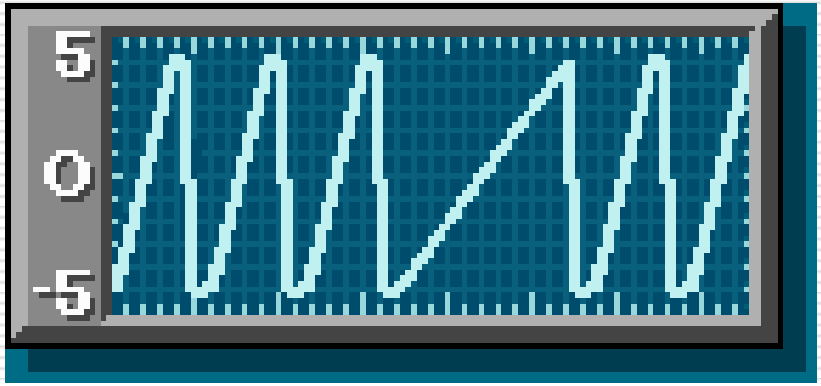


- Uses electromagnetic properties to produce its AC signal.
- As the ferrous material enters the magnetic field it produces a positive voltage.
- As the ferrous material exits the field it produces a negative voltage.

Magnetic Pickup Sensor
VRS



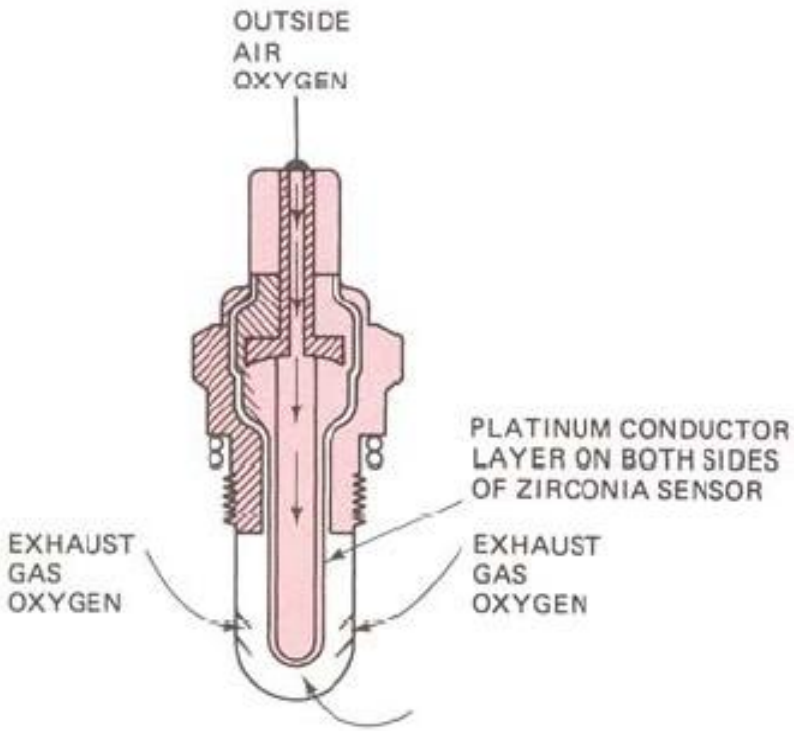
Magnetic Pickup Sensor VRS



- The CKP and CMP sensor for engine operation has a shielding over the wiring to the PCM.
- This shielding is required to prevent any EMI (electromagnetic interference) from being induced into the wiring.

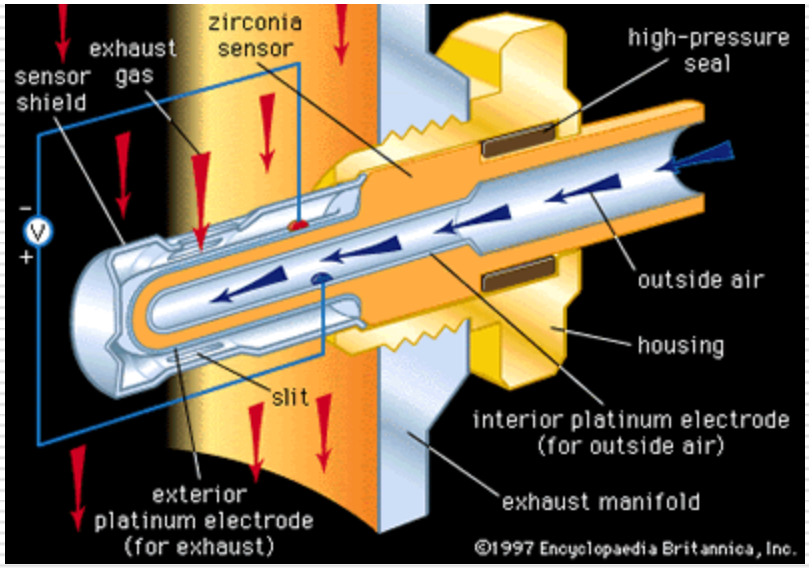
Oxygen Sensors
Lambda sensor

Oxygen Sensors
Lambda sensor



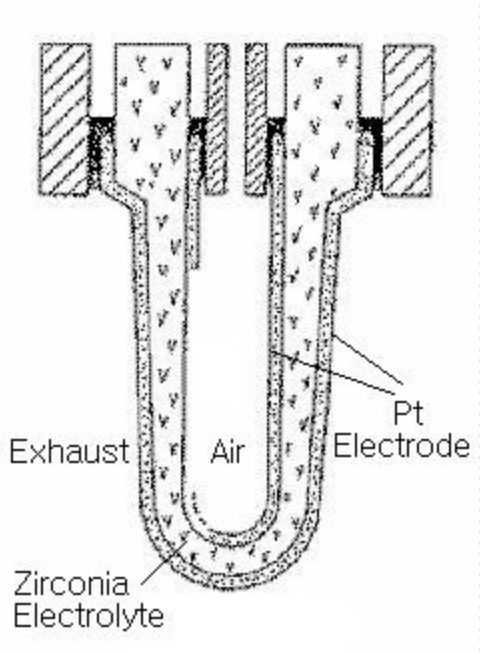
- Used to measure relative oxygen content in exhaust stream.
- This content directly relates to the air/fuel mixture used in the engine.

Oxygen Sensors
Lambda sensor



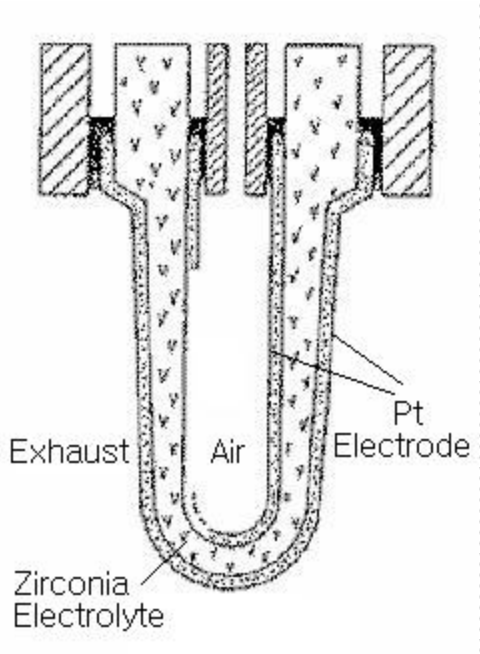
- Components:
  - Zirconia ceramic element
  - Heating element
  - Housing
  - Sensor shield (inner/outer)
  - Case seal
  - Wire seal
  - Wiring

Oxygen Sensors
Lambda sensor



- The difference in the amount of oxygen from inside to outside and the heat creates a voltage.
- Which condition has more oxygen remaining in the exhaust?
  - Lean
  - Rich
- Which condition has less oxygen remaining in the exhaust?
  - Lean
  - Rich

Oxygen Sensors
Lambda sensor



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  - **Lean**
  - Rich
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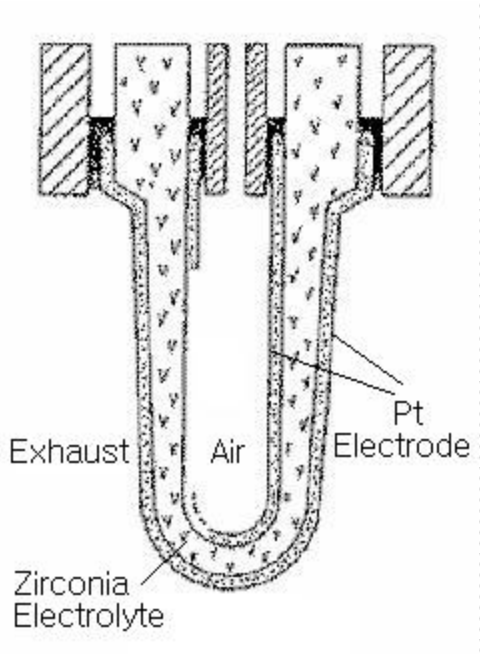
Oxygen Sensors
Lambda sensor

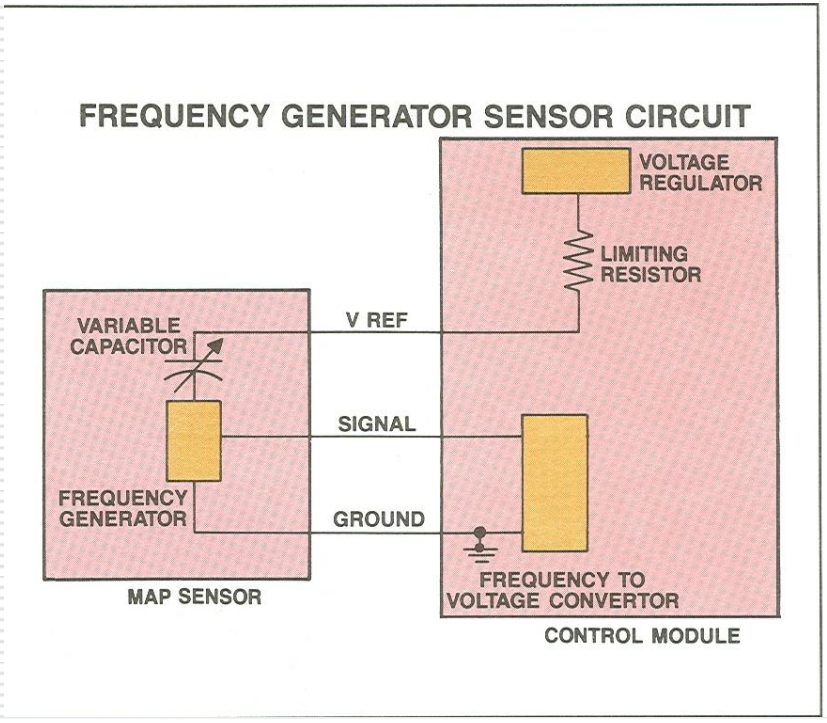


- The difference in the amount of oxygen from inside to outside and the heat creates a voltage.
- Which condition has more oxygen remaining in the exhaust?
  - **Lean**
  - Rich
- Which condition has less oxygen remaining in the exhaust?
  - Lean
  - **Rich**

Frequency Generator

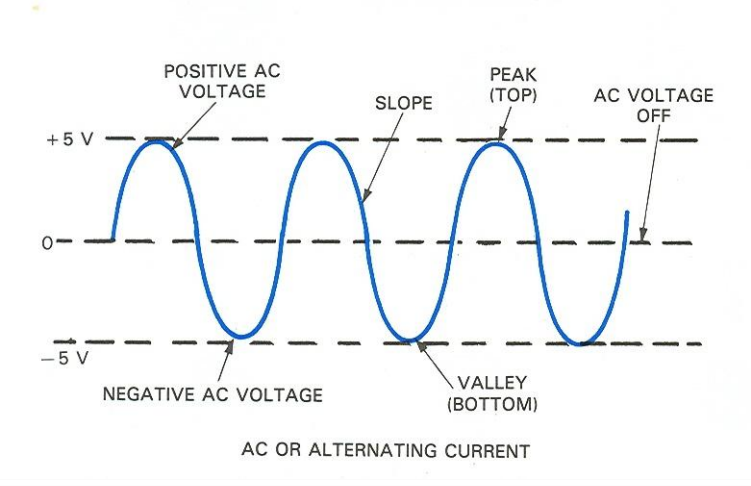
- A sensor that is used to monitor the atmospheric or manifold pressure for engine operations.
- This sensor supplies a 0 or 5 volt signal which changes many times a second.
- I supplies a frequency signal that relates to manifold vacuum.
- Idle= low frequency
- WOT= high frequency

Frequency Generator



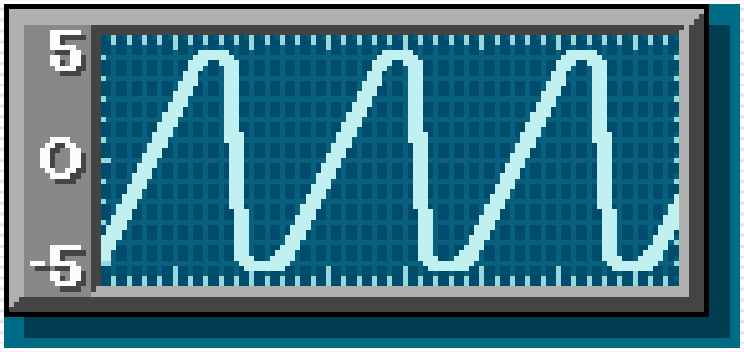
- The variable **capacitor** is acted upon by the pressure from the system.
- The frequency generator then changes its signal based on the variable capacitance.

Wave



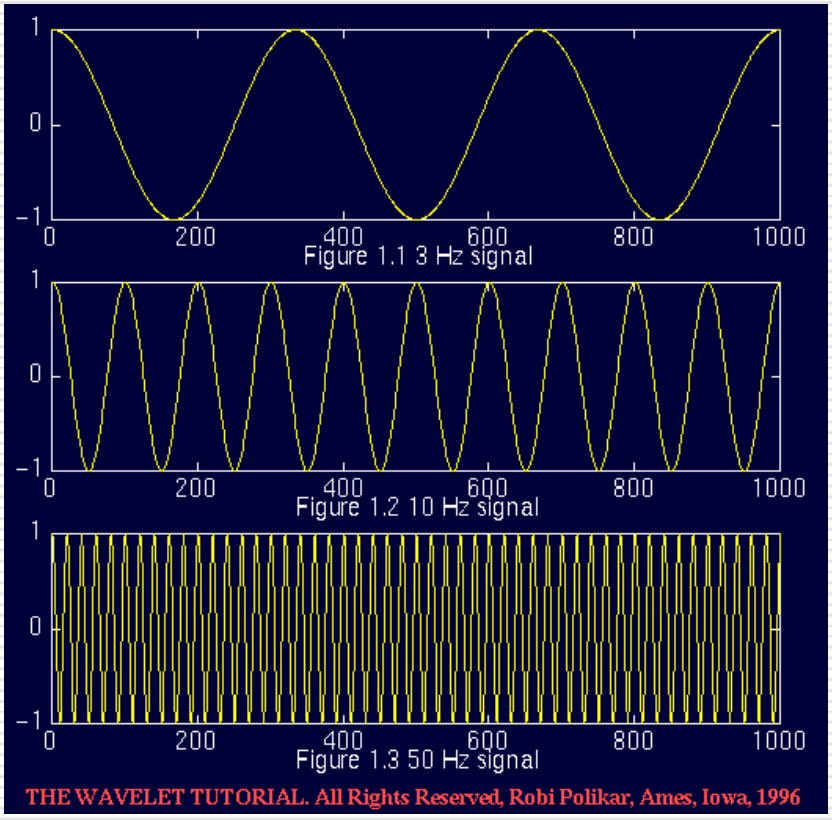
- A signal with a gradual increase or decrease which may repeat over time.
- Components:
  - Positive slope
  - Negative slope
  - Peak
  - Valley
  - Cycle
  - Period

Frequency



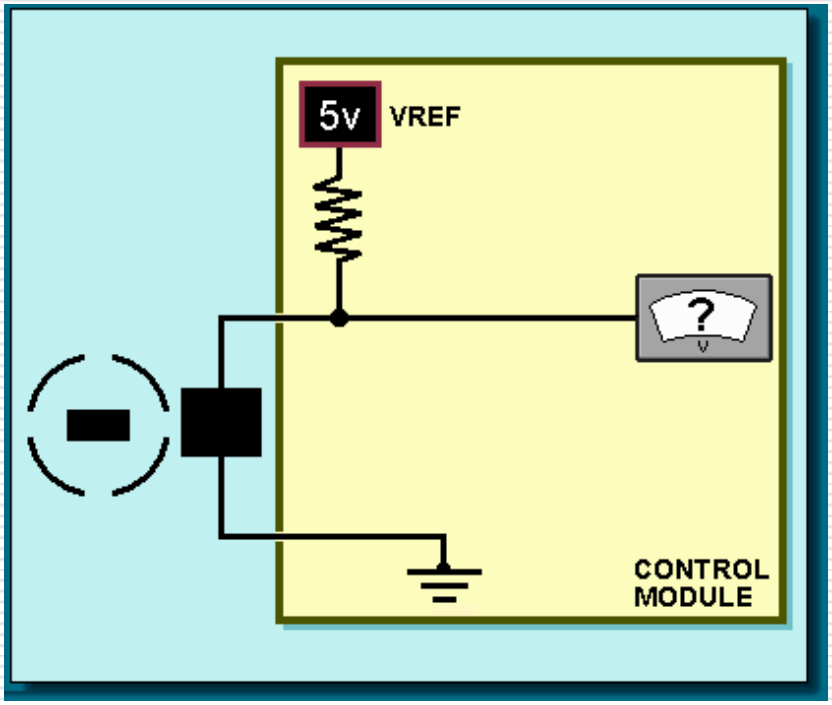
- How many times a signal cycles within one second.
- Measured in Hertz (Hz).
- Measured with:
  - DVOM Hz setting
  - Analog oscilloscope
  - Digital oscilloscope

Hertz



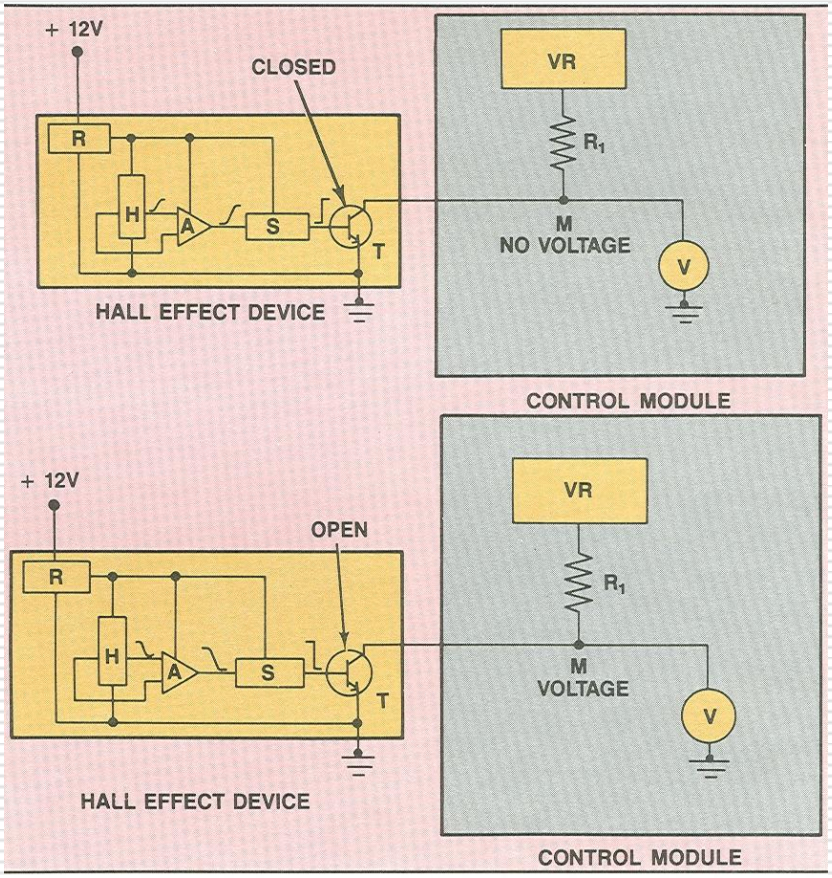
- To determine Hz:
  - Count number of times signal cycles.
  - Measure period of a cycle and divide into 1
  - Use DVOM Hz setting and measure.

Hall Effect Device.



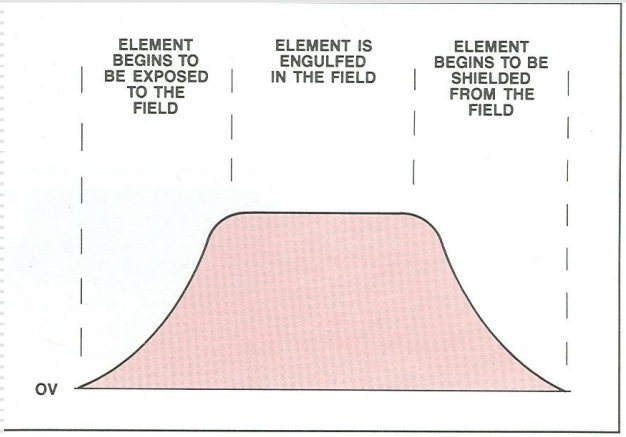
- A device which digitally indicates speed and position of a rotating component.
- Components:
  - Hall element
  - Schmitt trigger
  - Amplifier
  - Vane
  - Magnet

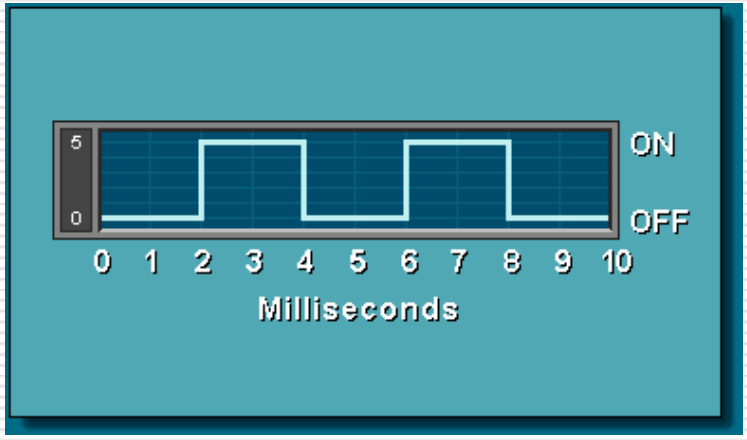
Hall Effect Device



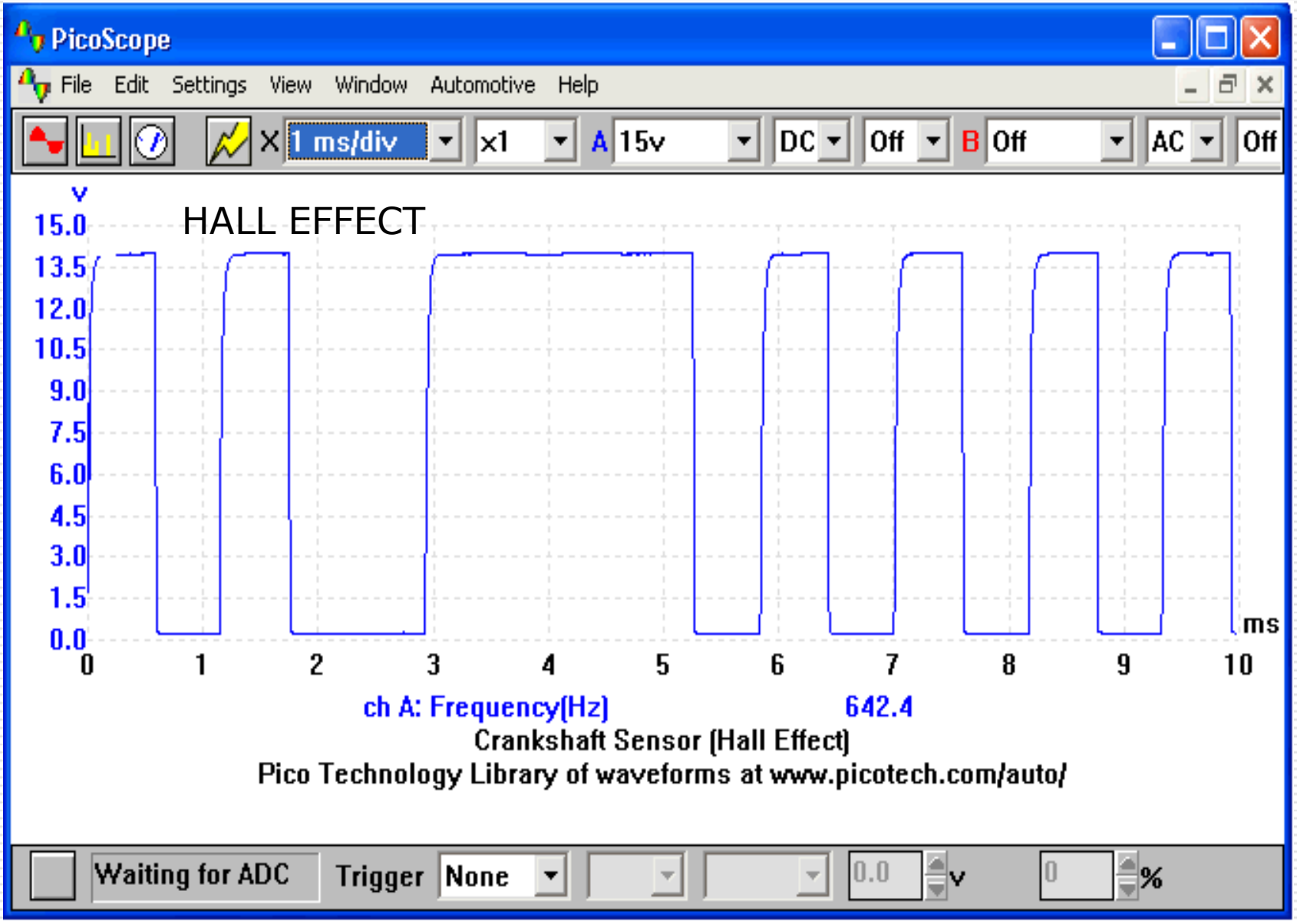
- Internal to the Hall Effect Device:
  - The hall element is acted upon by the ferrous exciter, this interaction creates an analog dc signal.
  - The analog dc signal is then converted to digital by the Schmitt trigger. It has trigger voltages that when they are reached the trigger turns on or off.
  - The ST then applies voltage to a NPN which applies ground to a sensor circuit.

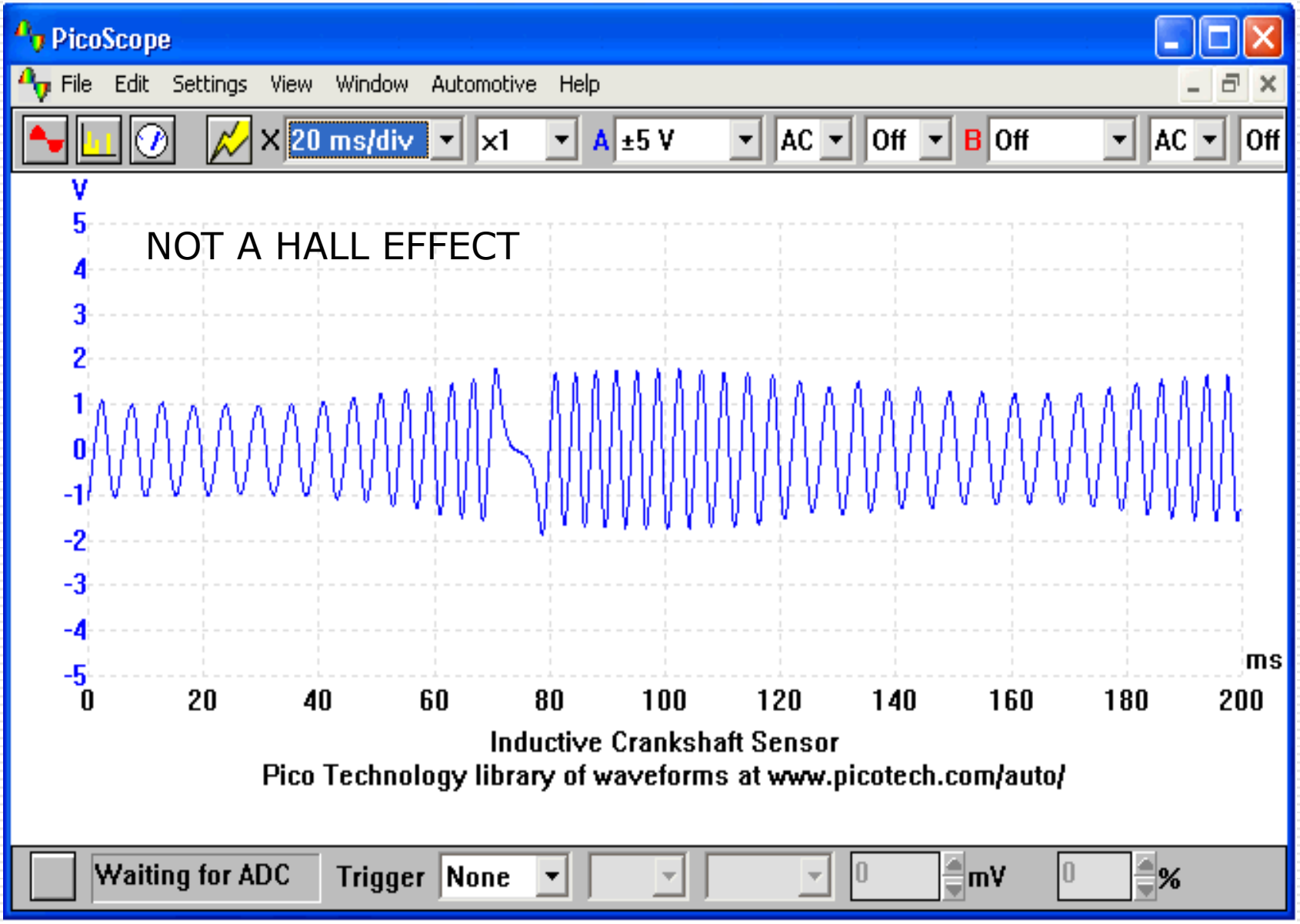
Hall Effect Device

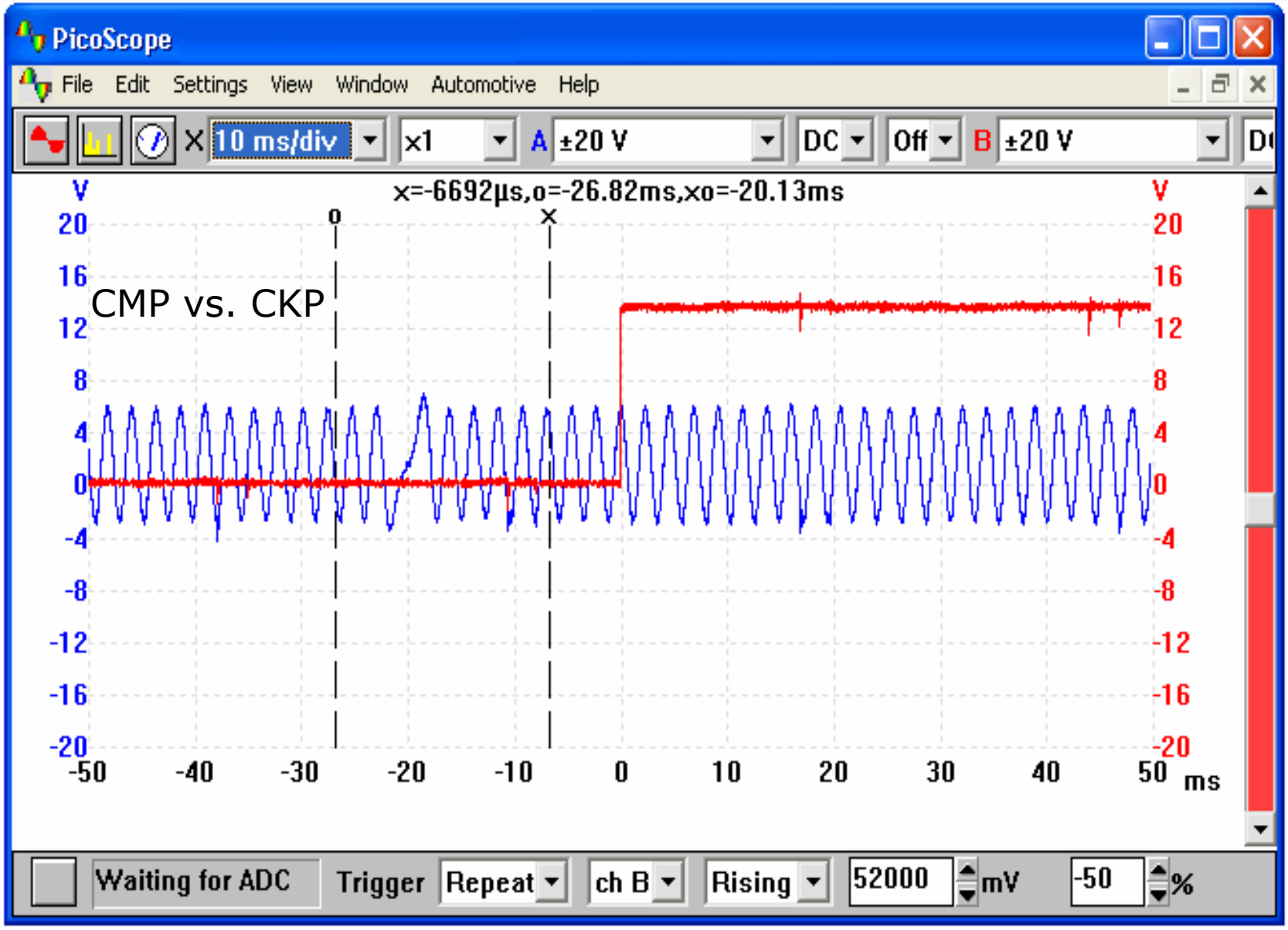




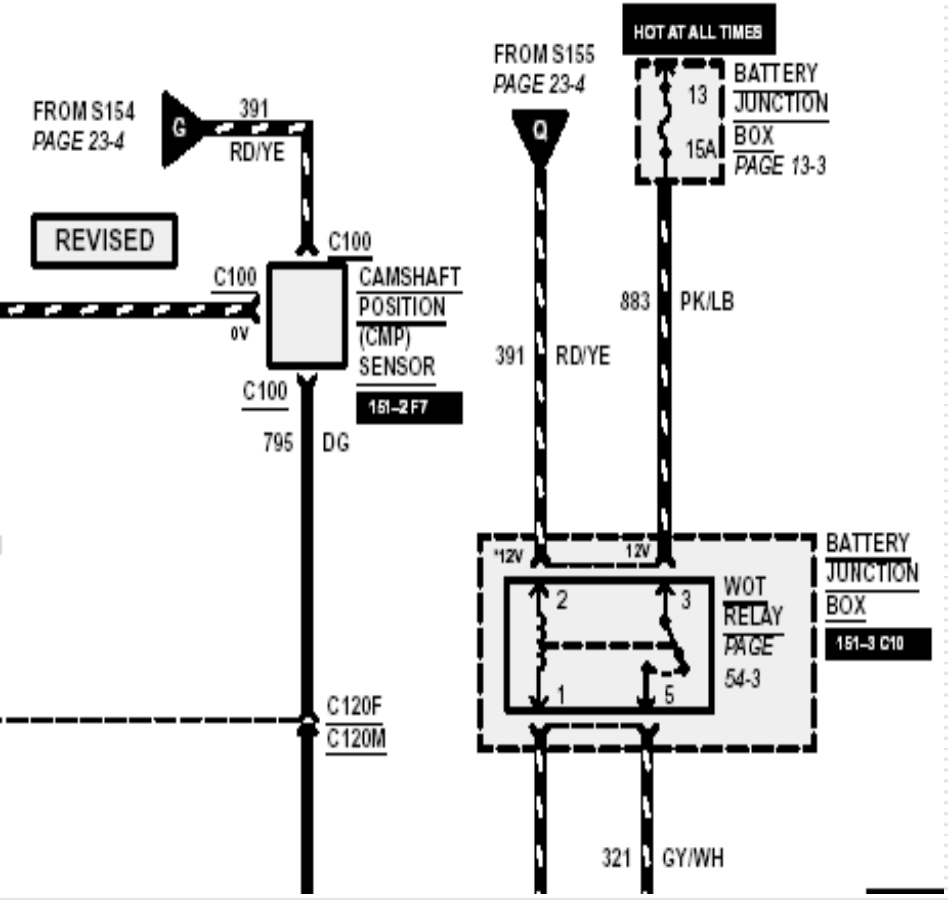
- The normal analog DC signal is kept internal to the sensor.
- The Schmitt trigger switches on and off at set points within the slopes of the analog DC signal.


PicoScope
File Edit Settings View Window Automotive Help
X 1 ms/div x1 A 15v DC Off B Off AC Off
V
HALL EFFECT
15.0
13.5
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
0 1 2 3 4 5 6 7 8 9 10
ms
ch A: Frequency(Hz) 642.4
Crankshaft Sensor (Hall Effect)
Pico Technology Library of waveforms at www.picotech.com/auto/
Waiting for ADC
Trigger None
0.0 V
0 %


PicoScope
File Edit Settings View Window Automotive Help
20 ms/div
x1
A ±5 V
AC
Off
B Off
AC
Off
NOT A HALL EFFECT
V
5
4
3
2
1
0
-1
-2
-3
-4
-5
ms
0 20 40 60 80 100 120 140 160 180 200
Inductive Crankshaft Sensor
Pico Technology library of waveforms at www.picotech.com/auto/
Waiting for ADC
Trigger
None
mV
%

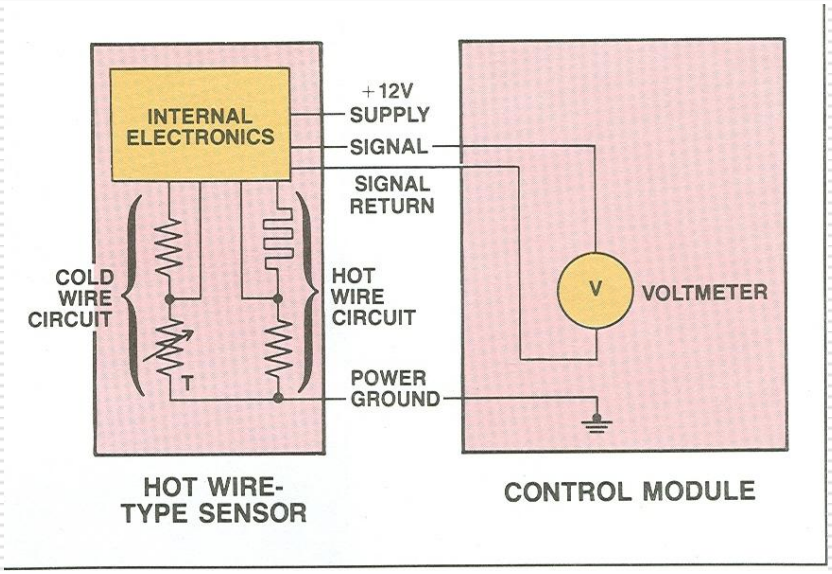

PicoScope
File Edit Settings View Window Automotive Help
X 10 ms/div x1 A ±20 V DC Off B ±20 V
x=-6692µs,o=-26.82ms,xo=-20.13ms
CMP vs. CKP
V
20
16
12
8
4
0
-4
-8
-12
-16
-20
-50 -40 -30 -20 -10 0 10 20 30 40 50 ms
Waiting for ADC
Trigger
Repeat
ch B
Rising
52000
mV
-50
%

Hall Effect Device



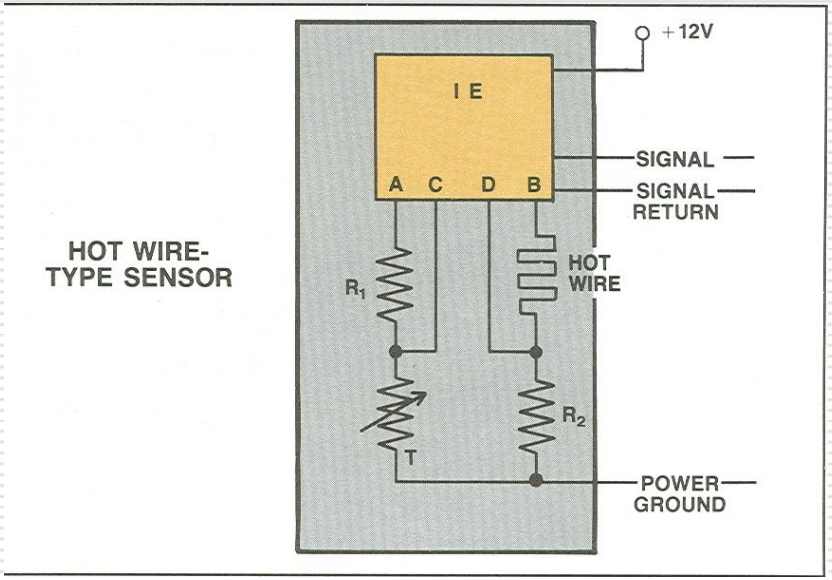
- The hall device uses only three wires. No VREF
- Circuits:
  - 391 = 12 volts
  - 795 = Hall Signal
  - 570 = Ground

Hot Wire sensor



- Used to measure the density of the incoming air to the engine.
- One wire within the MAF is heated to @300 F and the other wire is a sensor. The microprocessor uses the sensor wire to maintain the hot wire temperature. The greater the milliamps the denser the air.
- The MAF then conditions the signal to a 0 to 5 volt input to the PCM

Hot Wire Sensor



- Circuits
  - 12 volts
  - Ground
  - Signal
  - Signal return
- Some MAF sensors have six circuits due to the including of the IAT in the assembly.

Hot Wire Sensor

- Barometric pressure can be indirectly measured via a hot wire sensor.
- Initial key on event. The sensor heats up to 300° then meters the density of the air. How much amperage it requires to maintain temp. In addition to the MAF the PCM uses the IAT reading for air temperature to calculate the approximate value for Barometric pressure.
- Some sensors may also monitor the ramp up of amperage to heat the wire instead of maintaining the temp.